

FORM PTO-1390
(REV. 11-2000)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

P/61453-PCT

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/786036

INTERNATIONAL APPLICATION NO.
PCT/GB99/01594

INTERNATIONAL FILING DATE
05/20/1999

PRIORITY DATE CLAIMED
08/29/1998

TITLE OF INVENTION **CAMERAS**

APPLICANT(S) FOR DO/EO/US **Simon Howard SPENCER**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371 (f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
 - a. ☐ is attached hereto.
 - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☐ Other items or information:

U.S. APPLICATION NO. (if known) 09/786036		INTERNATIONAL APPLICATION NO. PCT/GB99/01594		ATTORNEY'S DOCKET NUMBER P/61453-PCT	
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21. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :
 Neither international preliminary examination fee (37 CFR 1.482)
 nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
 and International Search Report not prepared by the EPO or JPO \$1,000.00

International preliminary examination fee (37 CFR 1.482) not paid to
 USPTO but International Search Report prepared by the EPO or JPO \$860.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO
 but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO
 but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00

International preliminary examination fee (37 CFR 1.482) paid to USPTO
 and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =

Surcharge of \$130.00 for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)).	<input type="checkbox"/> 20 <input type="checkbox"/> 30	\$0.00	
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CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$		
Total claims	16 - 20 =	0	x \$18.00	\$0.00		
Independent claims	2 - 3 =	0	x \$80.00	\$0.00		
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$0.00		
TOTAL OF ABOVE CALCULATIONS =				\$860.00		
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$0.00		
SUBTOTAL =				\$860.00		
Processing fee of \$130.00 for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492(f)).				\$0.00		
TOTAL NATIONAL FEE =				\$860.00		
Fee for recording the enclosed assignment (37 CFR 1.21 (h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +				\$0.00		
TOTAL FEES ENCLOSED =				\$860.00		
				Amount to be refunded:	\$	
				charged:	\$	

a. ☒ A check in the amount of \$860.00 to cover the above fees is enclosed.

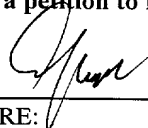
b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees.
 A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
 overpayment to Deposit Account No. 11-1145. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

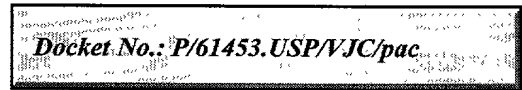
KIRSCHSTEIN, OTTINGER, ISRAEL & SCHIFFMILLER, P.C.
 489 Fifth Avenue
 New York, New York 10017
 (212) 697-3750

SIGNATURE: 

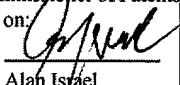
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PATENTS
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Alan Israel
Reg. No. 27,564

International Application No. : PCT/GB99/01594
International Filing Date : May 20, 1999
In re: Application of : Simon Howard SPENCER
Deposited : February 28, 2001
For : CAMERAS

New York, New York
February 28, 2001

PRELIMINARY AMENDMENT

BOX: PCT
Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

Prior to calculation of the filing fee and before examination, kindly amend the above captioned application as follows:

IN THE SPECIFICATION:

Page 1, between the title and the first line of text, insert the following heading:

-- BACKGROUND OF THE INVENTION --.

Page 3, at line 11, insert the following heading:

-- SUMMARY OF THE INVENTION --.

Page 4, at line 10, insert the following heading:

-- BRIEF DESCRIPTION OF THE DRAWINGS --.

Page 6, before line 1, insert the following heading:

--DETAILED DESCRIPTION OF THE
PREFERRED EMBODIMENTS --.

IN THE CLAIMS:

Page 16, change the subtitle "CLAIMS" to -- I CLAIM --.

Please cancel claims 1-17, without prejudice.

Please add the following new claims:

-- 18. A camera, comprising: a sensor for receiving radiation representative of a scene; filter means for attenuating the radiation reaching different spatial regions of the sensor to different extents; and decoding means for combining contributions to an output of the sensor from the different spatial regions, to produce a camera output of extended dynamic range.

19. The camera as claimed in claim 18, in which the sensor is operative for producing the output representative of lines of an image of the scene, and in which the filter means comprises stripes orientated so that lines of the stripes are inclined to the lines of the image.

20. The camera as claimed in claim 19, in which the stripes are inclined at an angle within a range of $\pm 45^\circ$ to $\pm 80^\circ$ to the lines of the image.

21. The camera as claimed in claim 20, in which the stripes are at approximately $\pm 45^\circ$ to the lines of the image.

22. The camera as claimed in claim 19, in which the stripes are neutral density stripes.

23. The camera as claimed in claim 19, in which the stripes are opaque.

24. The camera as claimed in claim 19, in which the stripes are colored.

25. The camera as claimed in claim 19, in which regions between the stripes are polarizing.

26. The camera as claimed in claim 19, in which regions between the stripes are transparent.

27. The camera as claimed in claim 19, in which there is a plurality of sets of stripes, each having different attenuating properties and being inclined at different angles to the lines of the image.

28. The camera as claimed in claim 19, in which the decoding means is operative for combining successive lines of the image to reinforce the image and cancel the contributions to an intensity of the stripes.

29. The camera as claimed in claim 19, in which the decoding means is operative for combining successive lines of the image to cancel the contributions to an intensity of the image and reinforce an intensity of the stripes.

30. The camera as claimed in claim 28, in which the decoding means comprises at least one comb filter.

31. The camera as claimed in claim 18, in which the sensor is a charge coupled device.

32. The camera as claimed in claim 18, in which the sensor includes an image intensifier.

33. A camera, comprising: a sensor for receiving radiation representative of a scene; filter means for attenuating the radiation reaching different spatial regions of the sensor to different extents; and decoding means for combining contributions to an output of the sensor from the different spatial regions, to produce a camera output of expanded contrast. --

IN THE ABSTRACT:

Delete the "Abstract" on the PCT cover sheet and replace it with the "Abstract of the Disclosure" set forth on a separate sheet attached hereto.

REMARKS

Headings have been added to the specification; an abstract has been provided on a separate sheet; and the claims have been amended to conform to U.S. practice.

Wherefore, an early action on the merits is earnestly solicited.

Respectfully submitted,

KIRSCHSTEIN, OTTINGER, ISRAEL & SCHIFFMILLER, P.C.

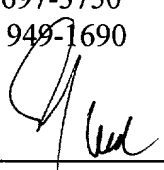
Attorneys for Applicant(s)

489 Fifth Avenue

New York, New York 10017-6105

Tel: (212) 697-3750

Fax: (212) 949-1690



Alan Israel

Registration No. 27,564

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ABSTRACT OF THE DISCLOSURE

A camera comprises a sensor such as a CCD or ICCD for receiving radiation representative of a scene, a filter such as an arrangement of parallel neutral density stripes, arranged to attenuate the radiation reaching the sensor, and decoding electronics such as comb filters which decode the encoded video output of the sensor, to produce a compressed video image, from which the pattern of the filter has been removed. --

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CAMERAS

This invention relates to cameras.

The invention is especially concerned with the dynamic range of such cameras.

5 TV cameras such as TV broadcast cameras, CCTV, domestic video cameras, are provided with various servo mechanisms to enable satisfactory video signals to be produced from the imaging device, usually a CCD sensor, from a wide range of scene illuminations. The most common servo mechanism is an auto-iris, and in fact these can cope with a large dynamic range, particularly if a transparent plate with an attenuating
10 region or regions in the iris plane, denoted a spotted iris, are employed. The tendency has however been for the dynamic range between different scene illuminations (inter-scene) to be dealt with by electronic shuttering. This means that in scenes of lower illumination, the CCD or other sensor is exposed for a full field of 20 milliseconds (ms) but with higher illumination the imager is gated so as to be exposed for perhaps only 2
15 microseconds (μ s).

Variations of illumination within a scene (intra-scene) present more problems. In a scene in which part is brightly illuminated and part is in shadow, if the region of shadow is of interest, then, if this signal is to occupy the full dynamic range of the
20 camera then the signals corresponding to the brightly illuminated region would greatly exceed the dynamic range of the camera, and therefore must either be clipped at peak level, thereby discarding the detail in the bright region, or compressed, thereby greatly

reducing the details in the dark region.

A multi-exposure technique has been demonstrated to overcome this problem (e.g. WO-A-94/18801). CCD sensors may be gated to take two exposures of the same scene with
5 different sensitivities e.g. 100:1 ratio. For example, alternate fields could be gated at 20 ms and 200 μ s. Combining these two fields produces a compressed picture. This technique is used for example when broadcasting sports events in which the action moves between one part of the ground in full sunlight and another part in shadow.

10 A drawback however is that the vertical resolution and temporal resolution are reduced with this technique.

Intra-scene dynamic ranges are of course decreased if the CCD sensor is used in conjunction with an image intensifier (ICCD), since the noise level is now increased. In
15 this case, imaging of scenes illuminated by starlight would be possible. Such an ICCD sensor has been disclosed in our patent application no. GB-A-2 318 012, in which coloured stripes were placed in front of the image intensifier, and processing electronics were used, to enable a monochrome sensor to produce a colour image.

20 If the double gating technique was extended to ICCDs as well as CCDs, there would be limitations about how fast the two exposures could be alternated. For example, if it was decided to expose twice within a field to reduce loss of vertical resolution, this might not be possible because of phosphor lag in the image intensifier. This is because an image intensifier has a photocathode on which an image is focussed, means such as a micro-

channel plate to multiply the number of electrons generated at the photocathode, and an anode on which the electrons impinge. The anode is coated with a phosphor to generate an optical image which is then picked up by a CCD. There is a limitation as to how fast the intensity of illumination of the phosphor can change.

5

The problem of double exposure with intensifiers could be solved by an arrangement of two intensifiers and a beam splitter passing, say, 90% intensity to one intensifier and 10% to the other. However, the cost and bulk of the camera would then increase, and the intensifier receiving the greater intensity of illumination would require replacement at more frequent intervals than the other.

10

The invention provides a camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of extended dynamic range.

15

The invention permits the disadvantage of reduced vertical resolution and temporal resolution to be avoided without recourse to using two image intensifiers.

20

The attenuating regions of the filter are preferably arranged in stripes, preferably non-parallel to the lines of the sensor, preferably inclined at around 45° to the lines. Analogue comb filters are preferably used to decode the encoded video signal produced by the sensor.

The reference to filter means attenuating to a different extent includes total attenuation (opaque), zero attenuation (transparent), and any degree between opaque and transparent, and also includes attenuation by neutral density, by colour, or by polarisation.

- 5 The invention also provides a camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of expanded contrast.

10

Cameras constructed in accordance with the invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

15

Figure 1 represents a subject it is desired to image, in which the subject has full contrast and there are no highlights;

Figure 2 represents a scene which is actually to be imaged, wherein highlights present reduce the contrast on the subject to a low level;

20

Figure 3 represents a low sensitivity image of the scene of Figure 2;

Figure 4 represents a high sensitivity image of the scene of Figure 2;

Figure 5 represents a combination of the images of Figures 3 and 4;

Figure 6 is a block diagram of the camera;

Figure 7 represents a typical line of encoded video signal;

5 Figure 8 represents an optical filter bearing a stripe pattern overlying the sensor of the camera;

Figure 9 shows a filter to extract the peak level of the encoded video without the influence of the stripes;

10

Figure 10 shows a filter to extract a signal representative only of the stripes from the encoded video signal;

Figure 11 shows a circuit for demodulating the output representative of the stripe pattern;

15

Figure 12 is a block circuit diagram of the decode electronics to produce a compressed video signal; and

20

Figure 13 shows a portion of the sensor of the camera showing a number of lines of the sensor on which are superimposed the image of the optical filter together with a representation of the brightness variation produced on the video signal by the stripe pattern, any distortion of the image intensifier being ignored.

Referring to Figures 1 to 5, the aim is to produce a high contrast image of a subject 1 (Figure 1), when the subject is viewed in the presence of a bright light 2, which has the effect of reducing the contrast on the subject to a very low level. This is achieved by imaging the scene at two different sensitivities. Thus, a low sensitivity image (Figure 3) is produced, as well as a high sensitivity image (Figure 4), and the two are combined to produce a compressed image, which shows a full range of contrast in the subject, but which nevertheless shows detail in the light as well.

In accordance with the invention, the images of different sensitivities are produced simultaneously by means of an optical filter (Figures 8 and 13) which attenuates the radiation reaching various spatial regions of a sensor. Thus, referring to Figure 6, the TV camera of the invention comprises a lens 3 arranged to image a scene onto the image plane of an ICCD, at which the stripes of an optical filter 4 in contact with the ICCD, are in focus. Electrical circuit 6 processes the output of the ICCD, which is a video signal which simultaneously contains a low sensitivity and a high sensitivity representation of the scene being viewed. This encoded video signal is decoded in Decode Electronics 7 to produce a compressed image as in Figure 5.

Referring to Figures 8 and 13, the stripes are inclined and of such an density as to attenuate the incident radiation to 1% of incident intensity. The filter is clear between the stripes allowing 100% of incoming radiation through.

It will be appreciated that if the camera was imaged on a scene of uniform intensity, the video signal for each line would consist of an approximately sinusoidal oscillation,

corresponding to the pitch of the stripes 8 (Figures 8 and 13) in the scan direction, with the envelope of the peaks of the sinusoids being level (i.e. the peaks having the same amplitude) corresponding to light illumination through the transparent regions between the stripes 8, and the envelope of the troughs of the sinusoids also being level and
5 corresponding to light transmission through the stripes 8 themselves. Note that the video signal would have an approximately sinusoidal fluctuation, as represented in Figure 13, rather than the square wave shape of the optical filtering on the line of the imager, because of filtering in the processing circuits.

10 In the imaging of an actual scene, the envelopes of the peaks and troughs of the sinusoids for each line will not be level. The envelope of the peaks of the sinusoids (A) for any particular line will correspond to the variation of spatial intensity of the high sensitivity image of Figure 4, while the envelope of the troughs of the sinusoids (B) will correspond to the variation of spatial intensity of the low sensitivity image of Figure 3. Thus,
15 referring to Figure 2 and Figure 7, for one particular line, the part of the envelope A denoted by A^1 , corresponds to a high sensitivity image of the subject 1 in Figure 2 i.e. as seen through the transparent region between the stripes, whereas the part of the envelope A denoted by A^2 , corresponds to the image of the light as seen through the transparent regions. The envelope A^1 varies and contains details of the intensity of the subject, while
20 the part of the envelope A^2 is level since it has been clipped and therefore does not contain any detail of the light source 2. This corresponds to the image of Figure 4.

The part of the envelope B denoted B^1 corresponds to the low sensitivity view of the image 1 seen through the stripes, and is of such a low value as to barely be above the

noise threshold. The part of the envelope B^2 is a low sensitivity image of the light 2 and corresponds to the light imaged through the stripes 8. This does contain detail. This corresponds to the image of Figure 3.

- 5 The encoded video signal records the envelope of the peaks A and also the depth of the oscillation ($B - A$).

The decode electronics 7 is shown in more detail in Figure 12 and consists of analogue comb filters 9 and 10 and demodulator 11. The optical filter 4 is imaged on the CCD sensor, and Figure 13 shows, on an enlarged scale, a portion of the filter pattern superimposed on four lines of a field L_n to L_{n+3} of the CCD sensor, together with a representation of the sinusoidal variation of intensity produced on the lines of the video signal by the image of the optical filter.

- 15 Referring to Figure 13, the attenuating stripes (B for "black") alternate with non-attenuating stripes (W for "white"), but there is one more of one sort than the other. Such a situation applies in Figure 13, although of course in reality there would be many more pairs of attenuating and non-attenuating stripes. The reason for the extra stripe is so that the intensity modulation impressed on, say, line L_{n+1} will follow on continuously from that impressed on line L_n . In the example shown, the last section of line L_n is non-attenuating, so the first section of line L_{n+1} is attenuating.
- 20

The sensor operates in a progressive scan mode i.e. lines L_n , L_{n+1} , L_{n+2} , L_{n+3} are consecutive and there is no interlacing.

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The decode electronic 7 operates in the following manner. In order to produce envelope A corresponding to the brightness of the high sensitivity image but with the stripe pattern removed, a transversal filter such as an analogue comb filter 9 sums the signals corresponding to adjacent lines e.g. L_n , L_{n+1} in analogue comb filter 9. This is achieved by adder 12 which sums the input directly received via link 14 and received via delay 13 which corresponds to one TV line ($64\mu s$). Referring to Figure 13, since the stripe pattern is in anti-phase on adjacent lines, the attenuation produced by this cancels, leaving only the brightness variation representative of the scene, which is reinforced since two lines are added. The output of comb filter 9 is thus output 2A.

10

The reason why the stripe pattern intensity is in anti-phase on successive lines is that the stripe pattern is inclined at 45° to the lines, and successive lines are spaced by half the wavelength of the stripe pattern.

15

In order to produce an output representing the difference between the modulation envelopes A and B, i.e. $|A - B|$, a transversal filter such as the comb filter in Figure 10 subtracts adjacent lines e.g. L_{n+3} , L_{n+2} to remove the overall brightness level of the scene whilst reinforcing the sinusoidal form of the stripe intensity modulation. Adjacent lines are subtracted at subtractor 15 by means of direct link 17 and delay 16 corresponding to one TV line ($64\mu s$). The output of this filter is the modulation corresponding to the depth of modulation of the sinusoids of the stripe pattern i.e. $|A - B|$. This signal is demodulated in diode detector 11 consisting of diode 18 and RC smoothing circuit 19.

20

20.

These two signals are combined at subtractor 21 (Figure 12). Since the output of the comb filter 9 is double the intensity of the scene, the resulting output from the decode electronic is the summation of the two envelopes A and B i.e. the required compressed image of Figure 5.

5

The sensitivity loss of having only half the sensor area fully sensitive is partly restored by the comb filtering benefits of noise i.e. 3db for single comb filter, 4.8db for a double filter.

- 10 Improved resolution can be obtained by the use of a third delay line 22 (delay $64\mu\text{s}$), shown dotted, the output of which is demodulated by a demodulator similar to that shown in Figure 11 but shown symbolically by diode 23. As an example, consider the arrival of line L_{n+2} at the input of comb filter 10. At the subtractor 15, line L_{n+1} is subtracted from it. The amplitude of the stripe pattern modulation is increased. At the diode 11, only
- 15 positive half cycles are passed i.e. the first, the third etc. At the same time, diode 23 is passing the positive cycles of the difference between lines L_{n+1} and L_n , this time only the second, fourth etc. half cycles. Thus, signal A-B is represented with increased resolution by combining signal A-B from diode detector 11 with signal (A-B)' from diode detector 23, so that there is signal present on each half cycle. Whereas the resolution of the low
- 20 sensitivity signal A - B has a bandwidth of approximately 1.8MHz, (the stripe pattern having a resolution of 3.5MHz), addition of the delayed stripe pattern (A - B)' gives a resolution of 3.5MHz.

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With a typical CCD array of 600 x 600 pixels, the filter may consist of 300 neutral density stripes alternating with transparent regions of the same width as the stripes, subject to there being one more or less neutral density than transparent stripe across the length of each line. The stripes are arranged at the image plane of the ICCD in such a way that when their shadow is cast on the CCD array, the stripes are orientated at 45° to the lines of the CCD array L_n etc. It is critical that the lines are aligned with each other for the purposes of the comb filters, but manufacturing tolerances mean that the stripes will not be arranged at exactly 45° to the lines of the CCD, manufacturing tolerances might also dictate that there are slightly more or less than 300 stripes crossing the top or sides of the CCD array, and there may also be slight uncertainties in the crystal frequency of the camera which is used to generate the line frequencies etc. It is for this reason that, during manufacture, the delay lines 13, 16 and 22 are trimmed in order to get an exact one line delay of 64µs between adjacent lines, and this can be done using a oscilloscope on the output 21.

15

It will be appreciated that other inclinations of the stripes to the ICCD lines are possible, so long as they are not vertical, since in this case there would not be a phase difference between one line and the next for the stripe modulation pattern, and its effects could not be removed. It will merely be necessary to trim the delay lines 13, 16 and 22 so that the modulation patterns of consecutive lines is in anti-phase to each other. Also, it is not necessary for the stripes to alternate with equal widths of transparent areas. Other mark/space ratios are possible. Further, the stripe filter need not be positioned at the focal plane of the ICCD, it may be positioned anywhere in the path of radiation onto the CCD sensor e.g. using relay lenses, so long as it is in focus on the image plane and may

in fact be formed directly on the CCD sensor. Further, it is not necessary for there to be the same number of stripes and transparent areas as there are lines of the sensor, there could be more or less stripes and alternating transparent regions than there are lines of the sensor.

5

In the embodiment described, the stripes only allow through 1% of light intensity. Of course, different densities are possible, and even the transparent region could be replaced by an attenuating region of different properties. In fact, opaque stripes i.e. 100% attenuation e.g. of aluminium, could be employed. Even though these stripes allow no light through at all, nevertheless there is a contribution to the output of the sensor, namely, due to noise $\left(\frac{1}{f}\right)$ particularly generated in the image intensifier but also in the CCD. This noise signal provides a black level reference which can be subtracted from the contribution to the output from the transparent regions, to compensate for temperature and $\left(\frac{1}{f}\right)$ noise.

15

Also, it is not necessary for the stripes to be of neutral density. They could be one particular colour e.g. blue, which would attenuate incandescent lights which radiate a large amount of red light.

20

Further, the stripes could be polarising, arranged to attenuate light of a particular polarisation. This could be a particular advantage in reducing reflections e.g. of light from a wet road surface.

Further, more than one set of stripes could be provided. For example, a second set of

different attenuating properties could be provided on the optical filter at a different angle to the lines of the sensor. Indeed, further sets of lines could be provided with different attenuating properties. In particular, a set of opaque stripes could be arranged with a set of 1% attenuating stripes. With one set of stripes, they could be inclined to the vertical of the raster as seen in Figure 13 at 22° , a second set could be arranged at -22° to the vertical, and a third set could be inclined at -45° to the vertical.

For example, a combination of stripes of neutral density, coloured (e.g. dark blue) and opaque could be used. The benefit of the invention (picture compression and extended dynamic range) would be both spectrally and scene responsive.

Further, one or more sets of stripes, provided to extend the dynamic range of the sensor in accordance with the invention, could be combined with coloured stripes as described in our earlier patent application no. 2 318 012 to produce a colour or pseudo colour output from a monochrome sensor. Indeed, two sets of coloured stripes could be provided; a first set of one attenuation to produce the colour output, and a second set of greater attenuation (the same colour but greater density) to extend the dynamic range. These could be set at different angles to the first set.

Variations may be made on the encoding (stripe patterns) and decoding to produce the signals A , $A - B$, $(A - B)^2$. There are benefits to be gained by using more sophisticated filtering in the decode electronics block 7. For example, double delay filters or triple delay filters may be used.

The regular pitch of the stripes gives the option of demodulation of the encoded video by the use of a circuit tuned to the frequency of the stripes.

In the described embodiment using ICCD, the image intensifier used produces a distortion of only 1/2% at the CCD sensor. However, there are other image intensifiers which produce a much greater geometric distortion e.g. 10%, in which case the stripe pattern of Figure 13 would be distorted by the image intensifier. Another alternative which would be useful in this case, would be for the decode electronics to use a memory map relying on stored signals to relate the pixels of the CCD sensor to the (distorted) stripe pattern falling on the CCD sensor, for example as described in our prior patent application no. 2 318 012. Indeed, if a memory map was used, the attenuating regions of the filter could be in any arrangement desired, not necessarily a stripe pattern.

As another alternative, it will be possible to modify the delay network to accommodate geometry distortion by providing a voltage variable delay having as its input a signal related to the geometric distortion of the ICCD. Non-linear tuned circuits e.g. level and/or frequency adaptive could be used e.g. to remove a low level stripe pattern.

The stripes may be placed in contact with the ICCD or a relay lens may be used to project their image onto the image plane of the ICCD.

In the embodiments referred to above, the imager is an ICCD. The ICCD sensor comprises as is well known a CCD array coupled e.g. by optical fibres to the phosphors on the output surface of an image intensifier. The striped pattern may be cemented to the

front surface of the intensifier, possibly using a fibre optic coupling. However, the invention is applicable also to CCD sensors which are not intensified. Further the invention is applicable to monochrome or colour sensors. However, in fact a wide variety of imagers may be used such as a CMOS imager, a tube such as a vidicon or
5 orthicon, sensors active in the UV region may be used, e.g. visible near infra-red or far infra-red. The invention has been described in relative to progressive scanning, but is also applicable to interlace scan.

Furthermore the sensor may be a non-imaging sensor e.g. for an infra-red intruder alarm.
10 Or the invention is applicable to optically-coupled thermal cameras in which the thermal signal is used to vary the intensity of light on a sensor e.g. by varying the polarising angle in a transducer.

The cameras described above are used for high contrast scenes where compression is
15 desirable. Some scenes, of lesser contrast, will benefit from the invention as well. Very low contrast scenes, such as "misty" viewing conditions, will not show any benefit from the cameras. A small change to the cameras described above can accommodate very low contrast scenes. When the subtractor 15 in Figure 12 is changed to be positive i.e. an adder, the camera becomes an expander of contrast. Some imaging sensors have a non-
20 linear compression response (e.g. specially fabricated CCD devices). These special devices could be converted to a linear response by using the expansion improvement. In fact, the cameras described above could be provided with a switch to enable the contrast expander option to be selected as desired.

CLAIMS

1. A camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of extended dynamic range.
2. A camera as claimed in Claim 1, in which the sensor is arranged to produce an output representative of lines of the image, and the filter means comprises stripes orientated so that the lines of the stripes are inclined to the lines of the image.
3. A camera as claimed in Claim 2, in which the stripes are inclined at an angle within the range $\pm(45^\circ$ to $80^\circ)$ to the lines of the image.
4. A camera as claimed in Claim 3, in which the stripes are at approximately $\pm 45^\circ$ to the lines of the image.
5. A camera as claimed in any one of Claims 1 to 4, in which the stripes are neutral density stripes.
6. A camera as claimed in any one of Claims 1 to 4, in which the stripes are opaque.
7. A camera as claimed in any one of Claims 1 to 4, in which the stripes are

coloured.

8. A camera as claimed in any one of Claims 1 to 4, in which the stripes are polarising.

9. A camera as claimed in any one of Claims 2 to 8, in which the regions between the stripes are transparent.

10. A camera as claimed in any one of Claims 1 to 9, in which there are two or more sets of stripes, each have different attenuating properties, inclined at different angles to the lines of the sensor.

11. A camera as claimed in any one of Claims 1 to 10, in which the decoding means is arranged to combine successive lines of the image to reinforce the scene and cancel the contribution to the intensity of the stripes.

12. A camera as claimed in any one of Claims 1 to 11, in which the decoding means is arranged to combine successive lines of the image to cancel the contribution to the intensity of the scene and reinforce that of the stripes.

13. A camera as claimed in Claim 11 or Claim 12, in which the decoding means comprises one or more comb filters.

14. A camera as claimed in any one of Claims 1 to 13, in which the sensor is a CCD.

15. A camera as claimed in any one of Claims 1 to 14, in which the sensor includes an image intensifier.

16. A camera substantially as herein described with reference to and as shown in the accompanying drawings.

17. A camera comprising a sensor for receiving radiation representative of a scene, filter means arranged to attenuate the radiation reaching different spatial regions of the sensor to different extents, and decoding means arranged to combine the contributions to the output of the sensor from the different regions, to produce an output of expanded contrast.

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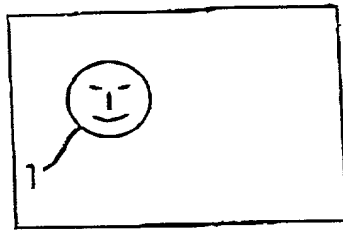


FIG. 1

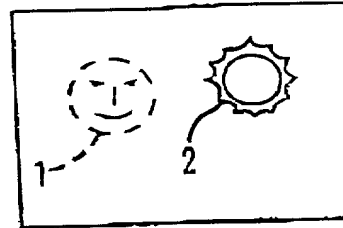


FIG. 2

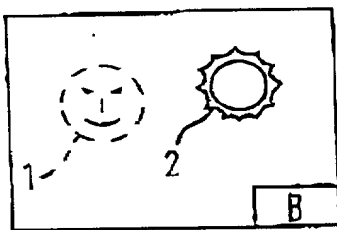


FIG. 3

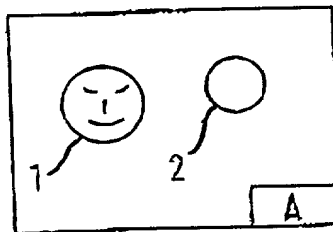


FIG. 4

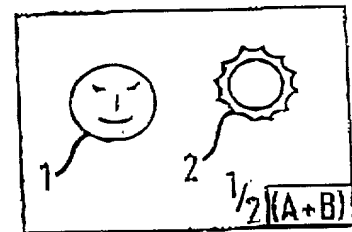


FIG. 5

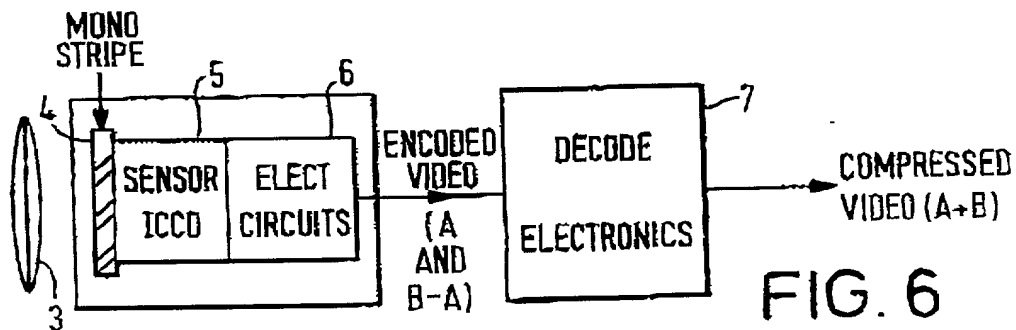


FIG. 6

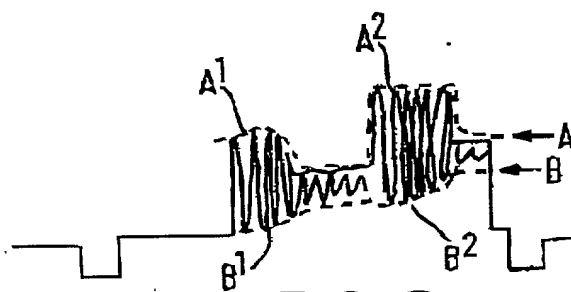


FIG. 7

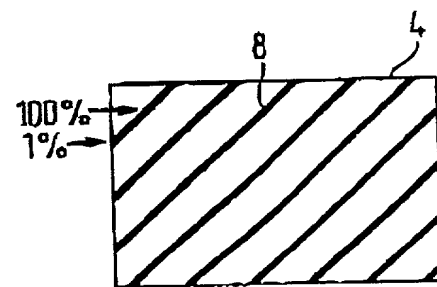
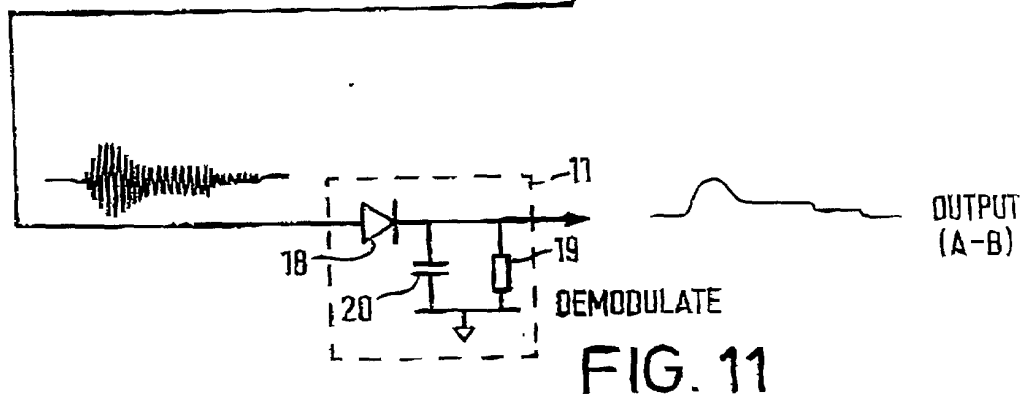
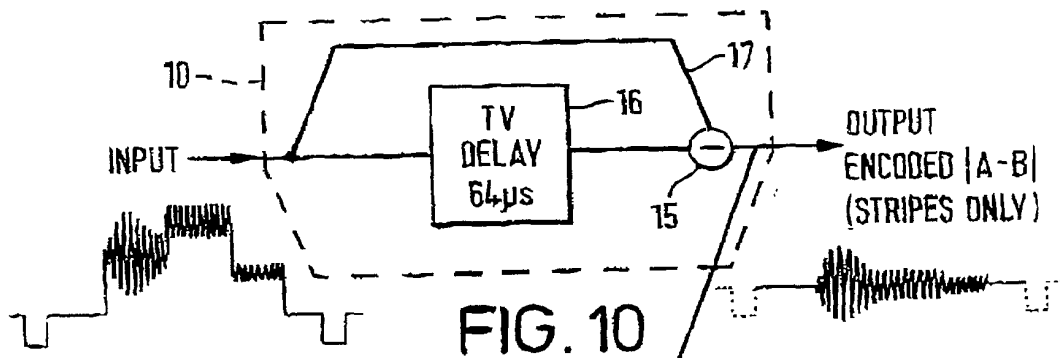
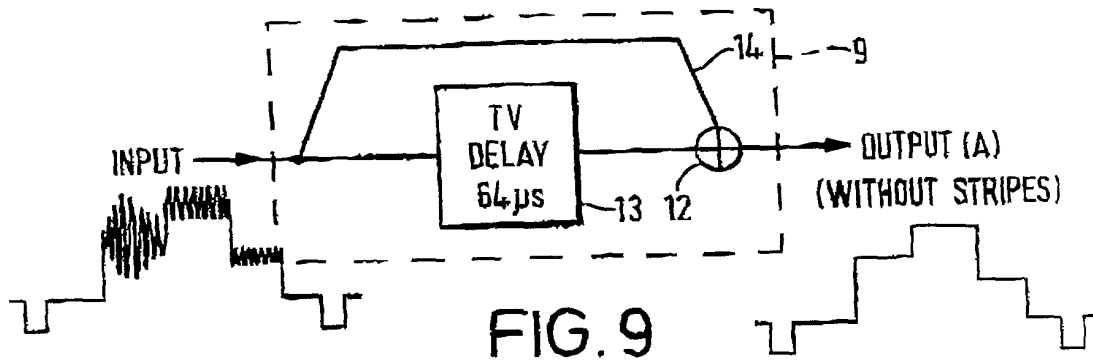
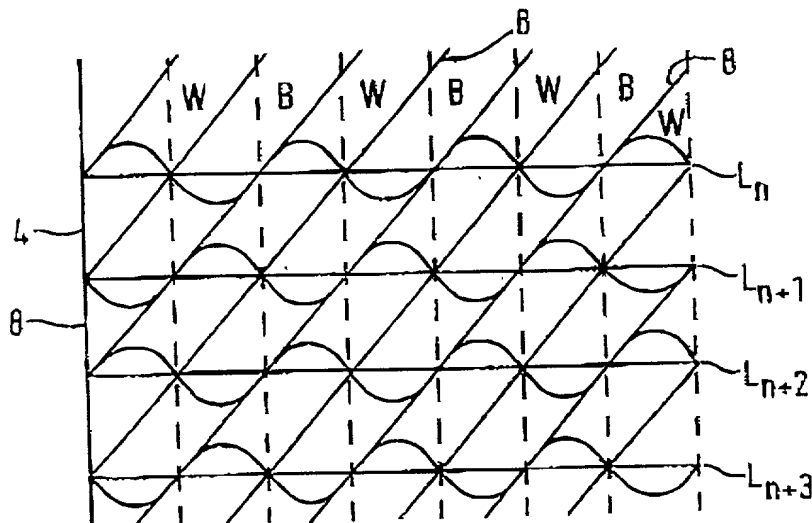
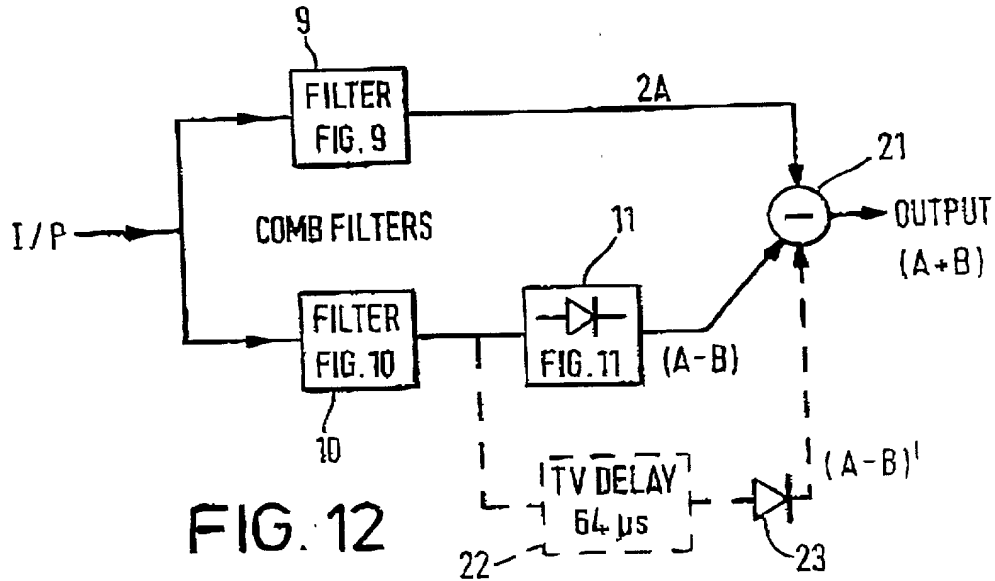


FIG. 8

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0010/PTO Rev. 6/95	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket Number	P/61453
DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION		First Named Inventor	S.Spencer
		COMPLETE IF KNOWN	
		Application Number	09/786,036
		Filing Date	February 28, 2001
		Group Art Unit	
<input type="checkbox"/> Declaration Submitted with Initial Filing <input checked="" type="checkbox"/> Declaration Submitted after Initial Filing		Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

CAMERAS

(Title of the Invention)

the specification of which

☐ is attached hereto
OR

☒ was filed on (MM/DD/YYYY)
February 28, 2001 &
20 May 1999

as United States Application Number or PCT International

Application Number

09/786,036 &
PCT GB99/01594

and was amended on (MM/DD/YYYY)

(if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code §119 (a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365 (a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached?	
				YES	NO
9818949.1 / PCT/GB99/01594	GB / International	Aug. 29, 1998 / May 20, 1999	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

☐ Additional foreign application numbers are listed on a supplemental priority sheet attached hereto.

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority sheet attached hereto.

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DECLARATION

Page 2

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s), or §365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

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☐ Firm Name OR ☐ Customer Number or label
☒ List attorney(s) and/or agent(s) name and registration number below:

Name	Registration Number	Name	Registration Number
David B. Kirschstein, Esq.	17,244		
Alan Israel, Esq.	27,564		
Martin W. Schiffmiller, Esq.	30,421		

☐ Additional attorney(s) and/or agent(s) named on a supplemental sheet attached hereto.

Please direct all correspondence to: ☐ Customer Number or label OR ☒ Fill in correspondence address below

Name KIRSCHSTEIN, OTTINGER, ISRAEL & SCHIFFMILLER, P.C.
Address 489 Fifth Avenue
Address
City New York State New York ZIP 10017-6105
Country United States Telephone (212) 697-3750 Fax (212) 949-1690

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name	<u>Simon</u>	Middle Initial	<u>H</u>	Family Name	<u>SPENCER</u>	Suffix e.g. Jr.	
Inventor's Signature	<u>[Signature]</u>					Date	<u>23/3/01</u>
Residence: City	<u>Chelmsford</u>	State	<u>GBX</u>	Country	<u>Essex, UK</u>	Citizenship	<u>GB</u> ✓
Post Office Address	<u>"Padarn", Hopping Jacks Lane, Danbury</u>						
Post Office Address	<u>Chelmsford, Essex, UK (GB)</u>						
City	<u>Chelmsford</u>	State		Zip	<u>CM3 4PD</u>	Country	<u>United Kingdom</u>
Applicant Authority							

☐ Additional inventors are being named on supplemental sheet(s) attached hereto

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